BELLCOMM, INC.
955 L'ENFANT PLAZA NORTH, S.W. WASHINGTON, D.C. 20024

B70 08022

SUBJECT: An Approach to J Mission Lunar Surface Traverse Design as Illustrated at Merriam Crater, Arizona - Case 320

DATE: August 4, 1970

FROM: P. Benjamin
J. C. Slaybaugh

ABSTRACT

The introduction of major hardware modifications for the Apollo J Missions will expand man's capability on the lunar surface, requiring a corresponding increase in the efforts devoted to surface operations planning. In particular, increased attention will be necessary in the area of LRV traverse design. A preliminary attempt to define a systematic approach to the interdisciplinary problem of traverse design is developed, consisting of the following basic steps:

1. Geologic interpretation of the region under study
2. Definition of broad geologic objectives
3. Definition of detailed geologic objectives
4. Identification of features of interest
5. Identification of candidate stations
6. Construction of a preliminary traverse path consistent with constraints
7. Assignment of activities to stations
8. Assessment of the traverse
9. Iteration of steps 6 through 8.

The construction of a traverse at a simulated lunar site, Merriam Crater, Arizona, provides a tangible example of each step proposed, as well as an overall illustration of a documented traverse complete with activities. In addition, the traverse developed here may also be used at the test site to aid in the development and evaluation of traverse procedures, for LRV system evaluation, for crew training, and for traverse demonstration for management personnel.

(NASA-CR-113353) AN APPROACH TO J MISSION LUNAR SURFACE TRAVERSE DESIGN AS ILLUSTRATED AT MERRIAM CRATER, ARIZONA (Bellcomm, Inc.) 35 p

N79-73335

Unclas
00/91 11864

FF No. 602 CR-113353 (CODE)
(NASA CR OR TMX OR AD [redacted]ATEGORY)

BELLCOMM, INC.
955 L'ENFANT PLAZA NORTH, S.W. WASHINGTON, D. C. 20024

B70 08022

SUBJECT: An Approach to J Mission Lunar Surface Traverse Design as Illustrated at Merriam Crater, Arizona - Case 320

DATE: August 4, 1970

FROM: P. Benjamin
J. C. Slaybaugh

MEMORANDUM FOR FILE

INTRODUCTION

The introduction of major hardware modifications for the Apollo J Missions will expand man's capabilities on the lunar surface. The extended LM will allow astronauts to increase their lunar surface staytime, the -7 PLSS and B/SLSS will extend the length of the EVA's and the available radius of operations, and the LRV and LCRU will permit the astronauts to travel farther on the lunar surface than was previously possible. This enhanced capability, however, will require a corresponding increase in the efforts devoted to surface operations planning. In particular, increased attention will be necessary in the area of LRV traverse design. This memorandum is a preliminary attempt to define a systematic approach to the traverse design process.

The approach developed consists of the following basic steps:

1. Geologic interpretation of the region under study
2. Definition of broad geologic objectives
3. Definition of detailed geologic objectives
4. Identification of features of interest
5. Identification of candidate stations
6. Construction of a preliminary traverse path consistent with constraints
7. Assignment of activities to stations
8. Assessment of the traverse
9. Iteration of steps 6 through 8.

As outlined, the process is interdisciplinary, combining the scientific interpretations of the geologist with the hardware analyses of the engineer. Each step is designed to be self-contained, while the overall framework affords a maximum opportunity for interchange and documentation. Should modification to an existing traverse be required, a repetition of the entire design process is not necessary. Instead, reasonable changes can be made using work already documented.

To illustrate the proposed approach a traverse is constructed at Merriam Crater near Flagstaff, Arizona, analogous to one of several such sorties envisioned for each J mission landing site. The area was chosen for its similarity to Marius Hills, one of the proposed J mission sites, as well as its availability as a test site for traverse demonstration. No attempt has been made in the traverse to provide a full-scale geologic investigation of the area, as the purpose of this memorandum is to delineate an approach to operational planning.

TRAVERSE DESIGN PROCESS

Unlike terrestrial geology, preliminary geological interpretation of planned lunar landing sites must by necessity be performed without physical access to the site. Photogeologic interpretation is therefore a primary tool for investigating lunar sites. In the Merriam traverse design process only the type of information which would be available from photogeologic interpretation has been used. A step by step description of the traverse design process outlined above, with a corresponding illustration of each step as used in the construction of the traverse at Merriam Crater follows.

1. Geologic Interpretation - This step is designed to provide the basic geologic model of the region under study. The model is, in turn, used to define both the broad and detailed geologic objectives for a given site. Factors such as geologic age, structural history, and regional setting are combined to provide an overall theory of the current geology at the site.

The area at Merriam Crater shown in Figure 1 is part of an assumed volcanic field some 2,000 square miles in area containing numerous apparent lava flows and cinder cones of suggested basaltic composition. In addition, a few large volcanic centers are evident, which are assumed to have produced more silicic lavas. The San Francisco volcanic field, of which Merriam Crater is a part, is assumed to be one of these volcanic centers. The region is geologically young, overlying older horizontal marine and sedimentary layers (Reference 1).

2. Broad Geologic Objectives - The broad objectives identify information required to investigate the basic geologic model used for the site. Acquisition of data required to determine age, regional setting and structural relationships is specified, without regard to the specific structures or methods required to compile the data. Thus, the general information required is defined, but no limitations are set which might be affected by operational or hardware modifications at a later point in the planning.

The broad geologic objectives at Merriam Crater are:

a. Acquire samples and study structural relationships of volcanic constructional land forms associated with the San Francisco volcanic field.

b. Determine the extent of magmatic differentiation at the site.

c. Perform age dating of the volcanic events.

3. Detailed Geologic Objectives - The detailed objectives define the techniques which should be employed to fulfill the broad objectives. Methods of obtaining data are detailed including the depth of information required to meet each objective.

The detailed geologic objectives at Merriam Crater are:

a. Describe and sample in detail several of each type of the major constructional features interpreted as volcanic.

b. Establish a local stratigraphic sequence by direct observation of local superposition and intersection relations.

c. Carry out traverse geophysics in support of the geologic investigations in order to establish subsurface structure bearing directly on the major geologic problems of the site (modified from Reference 2).

4. Geologic Features of Interest - Once detailed geologic objectives have been established, the physical geology of the site is examined in more detail to determine the types and frequency of major geologic units. Photogeologic interpretation can lead to an orthophotographic representation showing various classes of units and their interrelationships.

The Merriam Crater area exhibits four basic types of geologic features:

a. Cinder cones and volcanic vents

b. Lava flows

c. Air fall deposits

d. Surficial material

5. Identification of Candidate Stations - After identifying the major geologic units at the site, a set of candidate science stations is defined. Often these stations will be at interface points between the units identified in order to sample as many units as possible at one stop, or to determine the relationship between the units. As many candidate stations as possible are identified, and an attempt is made to provide redundancy of station types (e.g., interface of the same types of features) so that a choice among similar stations may be made to include those which will meet the geologic objectives within the operational constraints.

Figure 2 shows 60 candidate stations identified for the Merriam Crater area. The geology at each station is described in Table 1.

6. Construction of a Traverse Path - A LM landing point is chosen in the area of interest consistent with landing criteria with respect to approach path and landing ellipse terrain. If possible, the landing point should be central to the area of interest. The traverse is then designed by combining the objectives, features of interest, and possible stations, discussed above, with the required activities, constraints, and assumptions discussed in Appendices B and C. A preliminary traverse is constructed joining the minimum number of stations which can effectively fulfill mission objectives.

The final traverse designed for the Merriam Crater area is shown in Figure 3. The traverse is 16.8 km in length and reaches a maximum return distance to the LM of just under 3 km. The LM landing point is in a smooth, open field with a radius of about 1 km. The LM is visible from 8 of the 14 traverse stations. The station numbers correspond to the potential stations identified in Figure 2, except for station 30a, which is equivalent to the unit sampled by station 30 but in a position of greater convenience for the traverse.

Table 2 summarizes the times and distances associated with the traverse. Arrival and departure times at each station are indicated in elapsed EVA time. Consistent with the life support constraints discussed in Appendix C, the EVA is 6 hours and 50 minutes in length, with the traverse itself using 5 hours and 20 minutes. Riding the LRV consumes 2 hours and 6 minutes, while 3 hours and 14 minutes are spent at the sampling stations.

7. Assignment of Activities to Stations - A station type is determined and activities are assigned to each station depending upon its geologic and geographic characteristics. For instance, television would tend to be utilized at the geographic extremes of the traverse, at high altitude affording good surveillance of the area, and at stations where other requirements result in a long station time.

At some stations only a minimum amount of sampling is necessary to fulfill the scientific objectives. Other than generalized photography of the area there is no documentation of the samples required, and sample selection is almost at random. The total time at such a station is less than 5 minutes. A second type of station requires greater time but is designed for minimum overhead, and thus includes no television and minimum use of traverse science instrumentation. It includes a few documented samples and similar activities of relatively short duration. The final station type includes deployment of television and traverse science instrumentation, and is used when extensive investigation of a station is desired.

Appendix A contains individual station data sheets indicating the activities to be performed at each station on the Merriam Crater traverse. Each sheet contains the station number, its location on the grid in Figure 3 and a description of the geologic units at the station. In addition, the specific samples required, the experiments to be deployed, the photos to be taken, the communications to be established, and the operations to be undertaken, as well as the associated times for these activities, are indicated. The activities at each station are summarized in Table 3. The specific details of these activities are discussed further in Appendix B.

8. Assessment of the Traverse - Once the traverse stations and activities have been chosen, a feasibility analysis is performed to insure that the mission objectives have been met, consistent with the operational constraints. In particular, metabolic rates, EMU capabilities, communications and walkback constraints must be matched against each portion of the traverse. These constraints and their implications are discussed in more detail in Appendix C.

9. Iteration - Once a preliminary traverse has been constructed, adjustments to account for constraint violation, misallocation of time between science and operations, or variation in LM landing site are made by iterating steps 6 through 8. Additional stations and modifications are inserted as constraints and requirements permit. The structure defined here facilitates this process because the objectives of the mission and points which meet these objectives are defined. This permits modification of the traverse to be accomplished within a consistent and well defined framework which minimizes the effort required for such changes.

CONCLUSIONS

The traverse design process presented in this memorandum has been developed to provide a systematic approach to an interdisciplinary problem. A defined structure for interchange and documentation is presented in an effort to minimize time currently devoted to lengthy review and revision cycles. The actual construction of a traverse at a simulated lunar site provides a tangible example of each step proposed, as well as an overall illustration of a documented traverse complete with activities. In addition, the traverse developed herein may be used at the test site for several other operationally-oriented activities, including:

1. Evaluation and development of traverse procedures.

2. LRV systems development and evaluation.

3. Crew training.

4. Traverse demonstration for management personnel.

It is felt that the current work, though preliminary in nature, will prove useful in a variety of activities associated with J mission lunar surface planning.

Peter Benjamin
P. Benjamin

J. C. Slaybaugh
J. C. Slaybaugh

2032-PB/JCS-cds

REFERENCES

1. J. D. Strobell and E. W. Wolfe, "Field Test Site, Merriam Crater Area," in Reference Material for Demonstration of Lunar Surveying System, Roving Vehicles, and Data Facility Operations, USGS, Flagstaff, Arizona, September 29, 1969.

2. T. N. V. Karlstrom, "Preliminary Evaluation of Plans for Exporing the Moon's Marius Hills on Foot," USGS, Flagstaff, Arizona.

3. J. C. Slaybaugh, "Modular Timeline Elements for Lunar Roving Vehicle Traverse Station Stops," Bellcomm Memorandum for File B70-03072, March 24, 1970.

4. P. Benjamin, "Projected Activities at Science Stations for J Mission Traverse Planning," Bellcomm Memorandum for File, B70-04004, April 1, 1970.

5. P. Benjamin, "-7PLSS Capability Using Current MSC Data and Assumptions," Bellcomm Memorandum for File B70-06090, June 29, 1970.

FIGURE 1 - MERRIAM CRATER AREA

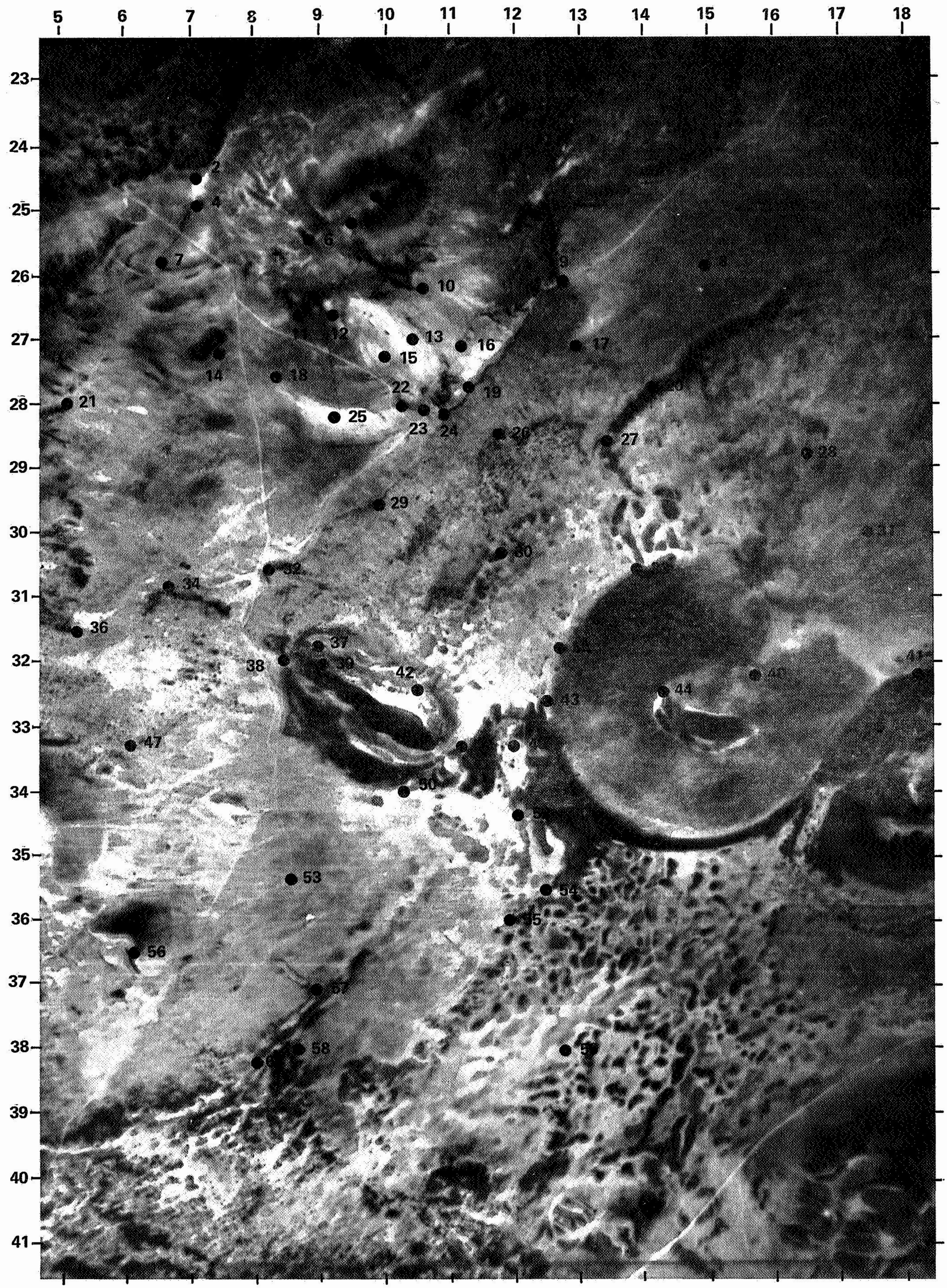

FIGURE 2 - SCIENTIFIC STATIONS OF INTEREST

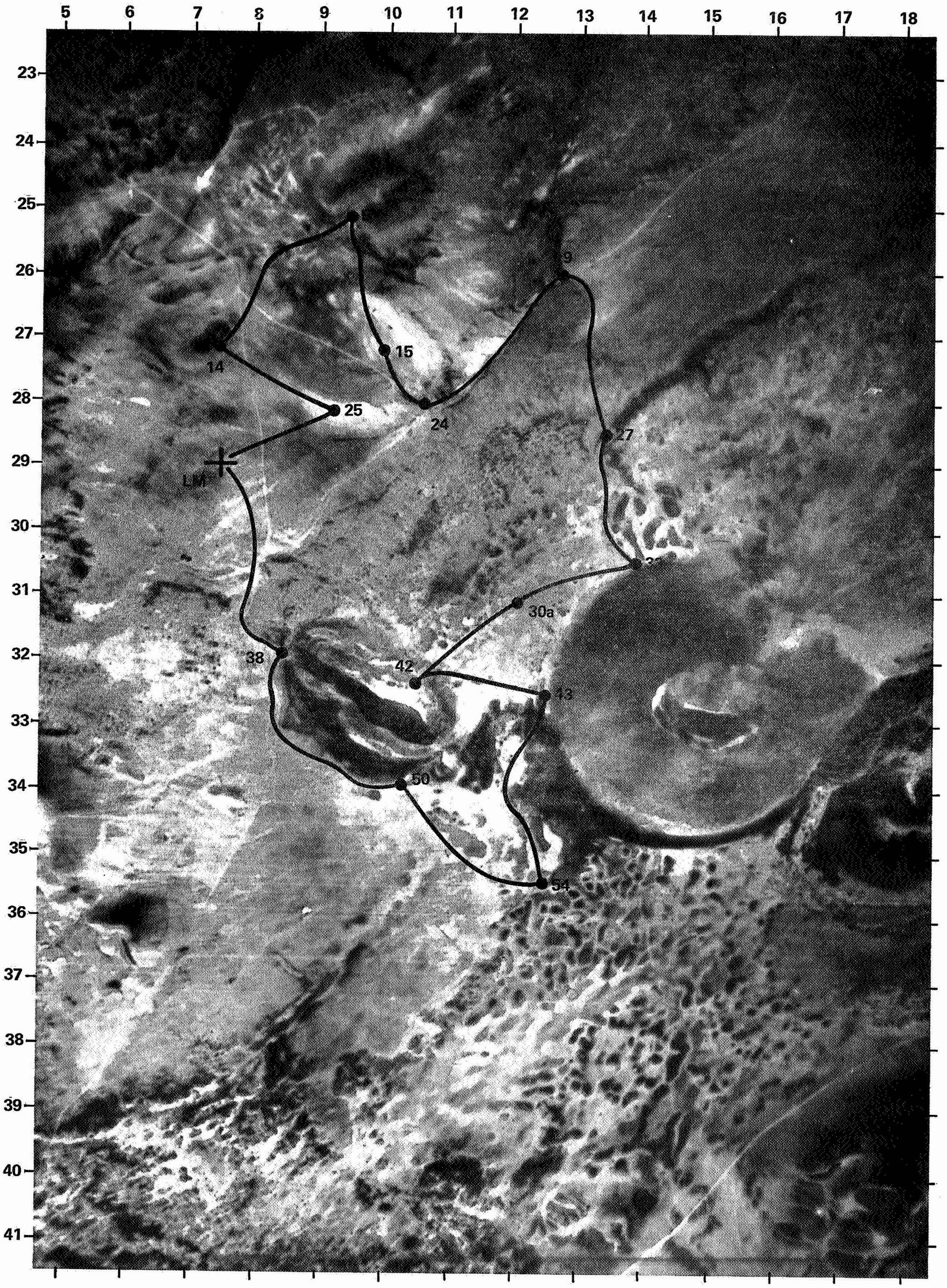

FIGURE 3 - MERRIAM CRATER TRAVERSE

TABLE 1

MERRIAM CRATER AREA STATION DESCRIPTIONS

STATION NO.	DESCRIPTION
1.	slope of cone
2.	junction of cone and two flows
3.	inside cone
4.	junction of cone, flow, and surficial deposit
5.	edge of cone at mouth
6.	flow field
7.	edge of cone at surficial deposit
8.	flow field
9.	triple flow contact
10.	flow edge at surficial deposit
11.	flow edge at tuff ring
12.	flow edge at tuff ring
13.	outside of tuff ring at surficial material
14.	flow structure
15.	outcrop of tuff ring
16.	small flow field
17.	edge of flow front on second flow
18.	tuff ring at surficial deposit
19.	double flow contact
20.	triple flow contact
21.	edge of cone
22.	tuff ring at flow
23.	edge of flow at tuff ring
24.	double flow contact at tuff ring
25.	tuff ring
26.	junction of two flows
27.	triple flow contact
28.	air fall at flow field
29.	flow edge at surficial material
30.	flow field
31.	air fall
32.	flow edge at surficial material
33.	junction of two flows at cone base
34.	flow edge at surficial material
35.	flow at cone base
36.	flow edge at surficial material
37.	flow at cone base
38.	multiple flows at cone mouth
39.	rim of cone
40.	mouth of cone
41.	flow at air fall
42.	mouth of cone at flow
43.	base of cone at flow
44.	cone rim
45.	double flow contact between two cones
46.	inside cone
47.	double flow at cone
48.	contact of two cones
49.	flow field
50.	contact of two cones at flow
51.	double flow contact at cone
52.	triple flow contact
53.	flow field
54.	triple flow contact
55.	triple flow contact
56.	flow at cone mouth
57.	double flow contact
58.	flow field
59.	flow field
60.	triple flow contact

TABLE 2

TRAVERSE SUMMARY

Station	Travel Distance (Km)	Travel Time (hrs:min)	Station Time (hrs:min)	EVA Time (hrs:min)	Cumulative Travel Distance (Km)
LM			0:45	0:45	
	1.5	0:11		0:56	1.5
38			0:12.5	1:08.5	
	1.6	0:12		1:20.5	3.1
50			0:03.5	1:24	
	1.2	0:09		1:33	4.3
54			0:23	1:56	
	1.4	0:10.5		2:06.5	5.7
43			0:03	2:09.5	
	0.7	0:05		2:14.5	6.4
42			0:23	2:37.5	
	1.0	0:07.5		2:45	7.4
30a			0:02.5	2:47.5	
	0.9	0:07		2:54.5	8.3
33			0:39	3:33.5	
	1.0	0:07.5		3:41	9.3
27			0:03	3:44	
	1.4	0:10.5		3:54.5	10.7
9			0:23	4:17.5	
	1.4	0:10.5		4:28	12.1
24			0:03.5	4:31.5	
	0.5	0:04		4:35.5	12.6
15			0:23.5	4:59	
	1.0	0:07.5		5:06.5	13.6
5			0:28	5:34.5	
	1.3	0:10		5:44.5	14.9
14			0:03	5:47.5	
	0.9	0:07		5:54.5	15.8
25			0:03	5:57.5	
	1.0	0:07.5		6:05	16.8
LM			0:45	6:50	

TABLE 3 - STATION ACTIVITY SUMMARY

STATION	ALIGN OMNI	ALIGN HIGH GAIN	NAVIGATION UPDATE	STATUS REPORT	TV	PAN PHOTO	PHOTO AREA	MAGNETOMETER	DOCUMENTED SAMPLES	GRAB SAMPLES	CORE TUBE	TRENCH SAMPLE	GAS ANALYSIS SAMPLE	MAGNETIC SAMPLE	SEISMIC PROFILING EXPERIMENT
38	√		√	√		√			2						
50	√		√	√			√			3					
54		√	√	√	√	√		√	3						
43	√			√			√			3					
42		√	√	√	√	√			3		√				
30a	√			√			√			2					
33		√	√	√	√				3			√	√	√	√
27	√			√			√			3					
9	√		√	√	√	√		√	3						
24	√		√	√			√			3					
15	√		√	√				√	3		√				
5		√	√	√	√	√			2		√	√			
14	√			√			√			2					
25	√			√			√			2					

APPENDIX A

Individual Station Data Sheets

STATION NUMBER 38

LOCATION X 8.5 RANGE TO LM 1.5

Y 32.0 AZIMUTH TO LM -19°

DESCRIPTION: Multiple flows at cone mouth

SAMPLES REQUIRED:

Documented 1. rim material
2. flow

TIME 7:00

EXPERIMENTS/PHOTOS:

Pan photo

TIME 2:00

OPERATIONS/COMMUNICATIONS:

Align omni antenna
Navigation update
Status report
Maintenance

TIME 3:30

TOTAL STATION TIME 12:30

STATION NUMBER 50

LOCATION X 10.3 RANGE TO LM 2.5

Y 33.9 AZIMUTH TO LM -31°

DESCRIPTION: Contact of two cones at flow

SAMPLES REQUIRED:

Grab 1. Sprouhl
2. cone
3. flow

TIME 1:30

EXPERIMENTS/PHOTOS:

Photo area

TIME 0:30

OPERATIONS/COMMUNICATIONS:

Align omni antenna
Navigation update
Status report
Maintenance

TIME 1:30

TOTAL STATION TIME 3:30

STATION NUMBER 54

LOCATION X 12.4 RANGE TO LM 3.1

Y 35.5 AZIMUTH TO LM -3.9°

DESCRIPTION: Triple flow contact

SAMPLES REQUIRED:

Documented 1. dark flow
2. mottled flow
3. light flow

TIME 10:00

EXPERIMENTS/PHOTOS:

Pan photo
Magnetometer

TIME 7:00

OPERATIONS/COMMUNICATIONS:

Align high gain antenna
Navigation update
Status report
Switch LCRU to TV
Maintenance

TIME 6:00

TOTAL STATION TIME 23:00

STATION NUMBER 43

LOCATION X 12.5 RANGE TO LM 2.3

Y 32.5 AZIMUTH TO LM -56°

DESCRIPTION: Base of cone at flow

SAMPLES REQUIRED:

Grab 1. dark flow
2. light flow
3. Merriam

TIME 1:30

EXPERIMENTS/PHOTOS:

Photo area

TIME 0:30

OPERATIONS/COMMUNICATIONS:

Align omni antenna
Status report
Maintenance

TIME 1:00

TOTAL STATION TIME 3:00

STATION NUMBER 42

LOCATION X 10.5 RANGE TO LM 1.7

Y 32.4 AZIMUTH TO LM -43°

DESCRIPTION: Mouth of cone at flow

SAMPLES REQUIRED:

Documented
1. rim
2. inside
3. mouth

Core tube in mouth or rim

TIME 15:00

EXPERIMENTS/PHOTOS:

Pan photo

TIME 2:00

OPERATIONS/COMMUNICATIONS:

Align high gain antenna
Navigation update
Status report
Switch LCRU to TV
Maintenance

TIME 6:00

TOTAL STATION TIME 23:00

STATION NUMBER 30a

LOCATION X 11.9 RANGE TO LM 1.8

Y 31.1 AZIMUTH TO LM -67°

DESCRIPTION: Flow field

SAMPLES REQUIRED:

Grab 1. flow
2. flow

TIME 1:00

EXPERIMENTS/PHOTOS:

Photo area

TIME 0:30

OPERATIONS/COMMUNICATIONS:

Align omni antenna
Status report
Maintenance

TIME 1:00

TOTAL STATION TIME 2:30

STATION NUMBER 33

LOCATION X	13.9	RANGE TO LM	2.5
Y	30.6	AZIMUTH TO LM	-78°

DESCRIPTION: Junction of two flows at cone base

SAMPLES REQUIRED:

Documented
1. Merriam
2. high flow
3. low flow

Magnetic
Gas analysis
Trench

TIME 28:00

EXPERIMENTS/PHOTOS:

Seismic profiling

TIME 5:00

OPERATIONS/COMMUNICATIONS:

Align high gain antenna
Navigation update
Status report
Switch LCRU to TV
Maintenance

TIME 6:00

TOTAL STATION TIME 39:00

STATION NUMBER 27

LOCATION X 13.4 RANGE TO LM 2.3

Y 28.5 AZIMUTH TO LM -96°

DESCRIPTION: Triple flow contact

SAMPLES REQUIRED:

Grab 1. high flow
2. medium flow
3. low flow

TIME 1:30

EXPERIMENTS/PHOTOS:

Photo area

TIME 0:30

OPERATIONS/COMMUNICATIONS:

Align omni antenna
Status report
Maintenance

TIME 1:00

TOTAL STATION TIME 3:00

STATION NUMBER 9

LOCATION X 12.8 RANGE TO LM 24

Y 26.1 AZIMUTH TO LM -120°

DESCRIPTION: Triple flow contact

SAMPLES REQUIRED:

Documented
1. flow right
2. flow left
3. flow bottom

TIME 10:00

EXPERIMENTS/PHOTOS:

Pan photo
Magnetometer

TIME 7:00

OPERATIONS/COMMUNICATIONS:

Align high gain antenna
Navigation update
Status report
Switch LCRU to TV
Maintenance

TIME 6:00

TOTAL STATION TIME 23:00

STATION NUMBER 24

LOCATION X 10.6 RANGE TO LM 1.2

Y 28.2 AZIMUTH TO LM -108°

DESCRIPTION: Double flow contact at tuff ring

SAMPLES REQUIRED:

Grab 1. tuff ring
2. flow left
3. flow in ring dip

TIME 1:30

EXPERIMENTS/PHOTOS:

Photo area

TIME 0:30

OPERATIONS/COMMUNICATIONS:

Align omni antenna
Navigation update
Status report
Maintenance

TIME 1:30

TOTAL STATION TIME 3:30

STATION NUMBER 15

LOCATION X 9.8 RANGE TO LM 1.2

Y 27.3 AZIMUTH TO LM -130°

DESCRIPTION: Outcrop of tuff ring

SAMPLES REQUIRED:

Documented 1. tuff ring
2. outcrop
3. inside ring
Core tube in tuff ring

TIME 15:00

EXPERIMENTS/PHOTOS:

Magnetometer

TIME 5:00

OPERATIONS/COMMUNICATIONS:

Align omni antenna
Navigation update
Status report
Maintenance

TIME 3:30

TOTAL STATION TIME 23:30

STATION NUMBER 5

LOCATION X 9.4 RANGE TO LM 1.6

Y 25.2 AZIMUTH TO LM -155°

DESCRIPTION: Edge of cone at mouth

SAMPLES REQUIRED:

Documented 1. cone
2. flow

Core tube in cone
Trench

TIME 20:00

EXPERIMENTS/PHOTOS:

Pan photo

TIME 2:00

OPERATIONS/COMMUNICATIONS:

Align high gain antenna
Navigation update
Status report
Switch LCRU to TV
Maintenance

TIME 6:00

TOTAL STATION TIME 28:00

STATION NUMBER 14

LOCATION X 7.3 RANGE TO LM 0.8

Y 27.2 AZIMUTH TO LM -115°

DESCRIPTION: Flow structure

SAMPLES REQUIRED:

Grab 1. structure
2. flow

TIME 1:00

EXPERIMENTS/PHOTOS:

Photo area

TIME 0:30

OPERATIONS/COMMUNICATIONS:

Align omni antenna
Status report
Maintenance

TIME 1:00

TOTAL STATION TIME 3:00

STATION NUMBER 25

LOCATION X 9.2

Y 28.2

RANGE TO LM 0.7

AZIMUTH TO LM +177°

DESCRIPTION: Tuff ring

SAMPLES REQUIRED:

Grab 1. tuff ring
2. tuff ring

TIME 1:00

EXPERIMENTS/PHOTOS:

Photo area

TIME 0:30

OPERATIONS/COMMUNICATIONS:

Align omni antenna
Status report
Maintenance

TIME 1:00

TOTAL STATION TIME 3:00

APPENDIX B

Activities

A summary of the activities to be carried out at each traverse station is shown in Table 3. Most of these activities, together with sampling station timelines, are discussed in more detail in references 3 and 4.

1. Operations - Navigation system updates are included in the operations portion of the station activities. The LRV navigation system displays range and azimuth to the LM to provide information for emergency return to the LM. Each individual station data sheet contains x and y values to aid in location of the station on the maps and range and azimuth values to match against LRV navigation system readings. Gyro drift in the navigation system requires that the system be updated approximately every half hour. The updating process involves aligning the LRV directly downsun, so that the sun shadow device on the LRV console is illuminated, and torquing the gyros to correct for the indicated error. Navigation updates require approximately 1 minute, during which no ingress/egress or loading/unloading operations may be performed on the LRV, navigation updates are normally scheduled as one of the last activities prior to leaving a station.

Status reports are included at all stations. The crew are requested to check and report LRV, LCRU, and PLSS status at these times. Status reports of experimental equipment and cameras, as well as film frame counts, are assumed to take place during use of that equipment. Additional maintenance and overhead activities are included in the operations category, including ingress/egress and loading/unloading operations.

2. Communications - At stations at which TV is scheduled for use, the high gain antenna must be deployed and aligned. The LCRU must also be reset to provide TV coverage. The activities associated with unstowing, aligning, and stowing the antenna and LCRU switching consume about 2 minutes of one crewman's time at a station at which TV is used. In addition, the LCRU must be brushed to remove dust at each stop. It is suggested that a target atop Merriam Crater may be appropriate for high gain antenna alignment during the simulated traverse. A relay station on Merriam could send the LCRU signal to Flagstaff, and then, possibly, to MSC for a full simulation.

While riding and at stations without TV the low gain antenna is used for communications. It is assumed that this antenna will be realigned whenever necessary upon ground request, but, at a minimum, will be realigned at any traverse stop at which the high gain antenna is not used.

3. Photography - The location and context of most stations are documented by photography. Panoramic photography is generally called for at longer stops and provides a full 360° record of the features visible from the station, as well as the local topography. Pan photos require about 2 minutes of station time. At shorter stations, area photography, or general documentation of interesting features and local terrain is called for. This requires half a minute or so. This photography is performed with the 70 mm Hassleblad camera. Use of the 16 mm sequence camera is optional, and considered to be part of operational overhead. Use of the ALCSC and LGEC is considered to be part of documented sampling.

4. Documented Samples - In order to establish the context within which a specific sample was obtained and to provide a detailed record of the exact position and orientation of the sample relative to its surroundings, photographs are taken of it with the LGEC prior to sampling and of the area from which it came after it has been removed. Documentation may be of an individual sample or of a generalized area from which a number of samples are collected.

Full documentation of one sample, including a reasonable period for sample location, selection, and bagging is assumed to take 3 minutes. An additional minute of overhead per station is charged for deployment and preparation of sampling equipment. The geologic unit from which samples are to be obtained is indicated in the individual station data sheet.

5. Grab Samples - At some stations only generalized photography of the area is required and no documentation of the sample is necessary. The samples are taken from a point well within a geologic unit, and two or three samples typical of the unit are gathered at random in the period of about a minute. The samples desired are listed on the individual station data sheet.

6. Core Tubes - A core tube provides data on subsurface layering and geologic and geochemical changes as a function of depth. A core tube is documented in a manner similar to that for a documented sample, and the whole process is assumed to take 5 minutes.

7. Trench Samples - The subsurface layering can also be examined and sampled in a trench. Larger and more extensive subsurface samples may be obtained by trenching than by core

tube, and generally multiple samples are taken from the sides and bottom of the trench. Area documentation is carried out, and trenching is allotted 8 minutes when called for at a station.

8. Magnetic or Gas Analysis Samples - In both magnetic and gas analysis sampling a variety of rocks is obtained away from points of possible contamination (such as the LRV) and is sealed in special containers. The location of the rocks is documented. The activity requires about 5 minutes for each sample.

9. Magnetometer - The anomalous magnetic field along the traverse is determined by means of the Lunar Portable Magnetometer. A sensor package is placed on a tripod 50 ft from the LRV, and the astronaut returns to the LRV to read the gauges on the electronics package. The cable connecting the sensor and the electronics package is then reeled up and the instrument is stowed. This process is assumed, optimistically, to consume 5 minutes.

10. Seismic Profiling Experiment - The lunar seismic profiling experiment uses seismology to attempt to determine the density and structure of subsurface geologic features. Explosive charges emplaced during the traverses are activated after liftoff and the seismic signals detected with a geophone array at the ALSEP. Deployment of the charge modules is called for at one point in this traverse, with 5 minutes allotted to this activity. Deployment consists of orientation of the package and setting a clock and/or throwing an activation switch.

APPENDIX C

Constraints and Assumptions

An attempt has been made to design this traverse in a manner consistent with the most recent program assumptions for EVA capability (Reference 5). Accordingly, metabolic rates of 700 Btu/hr for riding and 1050 Btu/hr for scientific and operational activities were assumed and calculated against a -7 PLSS capacity of 10.04 lbs of feedwater and 1.340 lbs of oxygen. A 30° sun elevation angle was used for EVA 3, and overhead at the LM at the beginning and end of the EVA was assumed to total 1.5 hours. Using an average LRV speed of 8 km/hr, the 16.8 km traverse planned here requires 2.1 hours of riding. The EVA is feedwater limited to a length of 6 hours and 50 minutes, leaving 3 hours and 14 minutes for activities at the stations when the 1-1/2 hours of overhead at the LM are accounted for. Figure C-1 is a plot of the EVA capability permitted by the consumables with the Merriam Crater traverse indicated.

At any point in the traverse the 2 crew members must be able to walk back to the LM from a failed LRV. This walkback requirement imposes a constraint upon the traverse such that sufficient PLSS consumables are always available to support an astronaut walking back to the LM at a metabolic rate of 1200 Btu/hr and a speed of 3.3 km/hr. This translates into a requirement for a PLSS reserve of 364 Btu/km of return distance to the LM. The 45 minutes of planned closeout activities at the LM following the traverse provides a 790 Btu pad which would still allow a 2.16 km walkback capability at the end of the traverse. Since the last 5 traverse stations are well within 2 km of the LM and the traverse never exceeds a 3 km return distance, the walkback requirement is met throughout with a large margin.

The crew must also be able to ride back to the LM using the B/SLSS in case of a PLSS failure at any point in the traverse. This rideback requirement imposes a constraint upon the traverse such that sufficient consumables remain in each PLSS to support both astronauts riding back to the LM at a total metabolic rate of 1400 Btu/hr and a speed of 8 km/hr. This translates into a requirement for a PLSS reserve of 175 Btu/km of return distance to the LM. Since this value is considerably less than the walkback reserve required, meeting the walkback requirement automatically provides a rideback capability.

The O_2 flow rate of the B/SLSS is limited to 1 hour riding duration resulting in a maximum rideback distance at 8 km/hr of 8 km. The rideback and walkback return distance constraints as a function of EVA time are plotted in Figure C-2, with the traverse also shown.

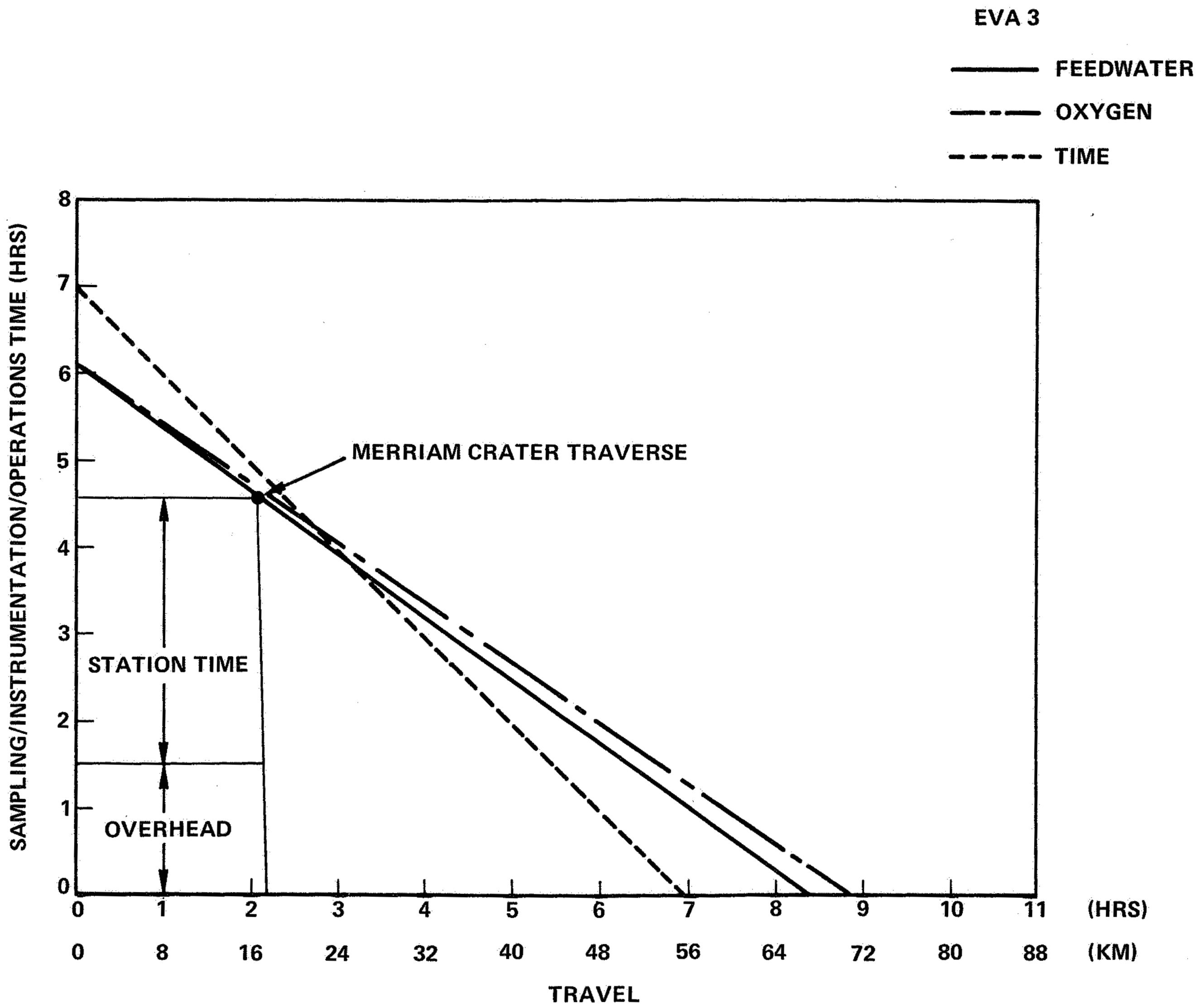

FIGURE C-1 - SYSTEM CAPABILITY

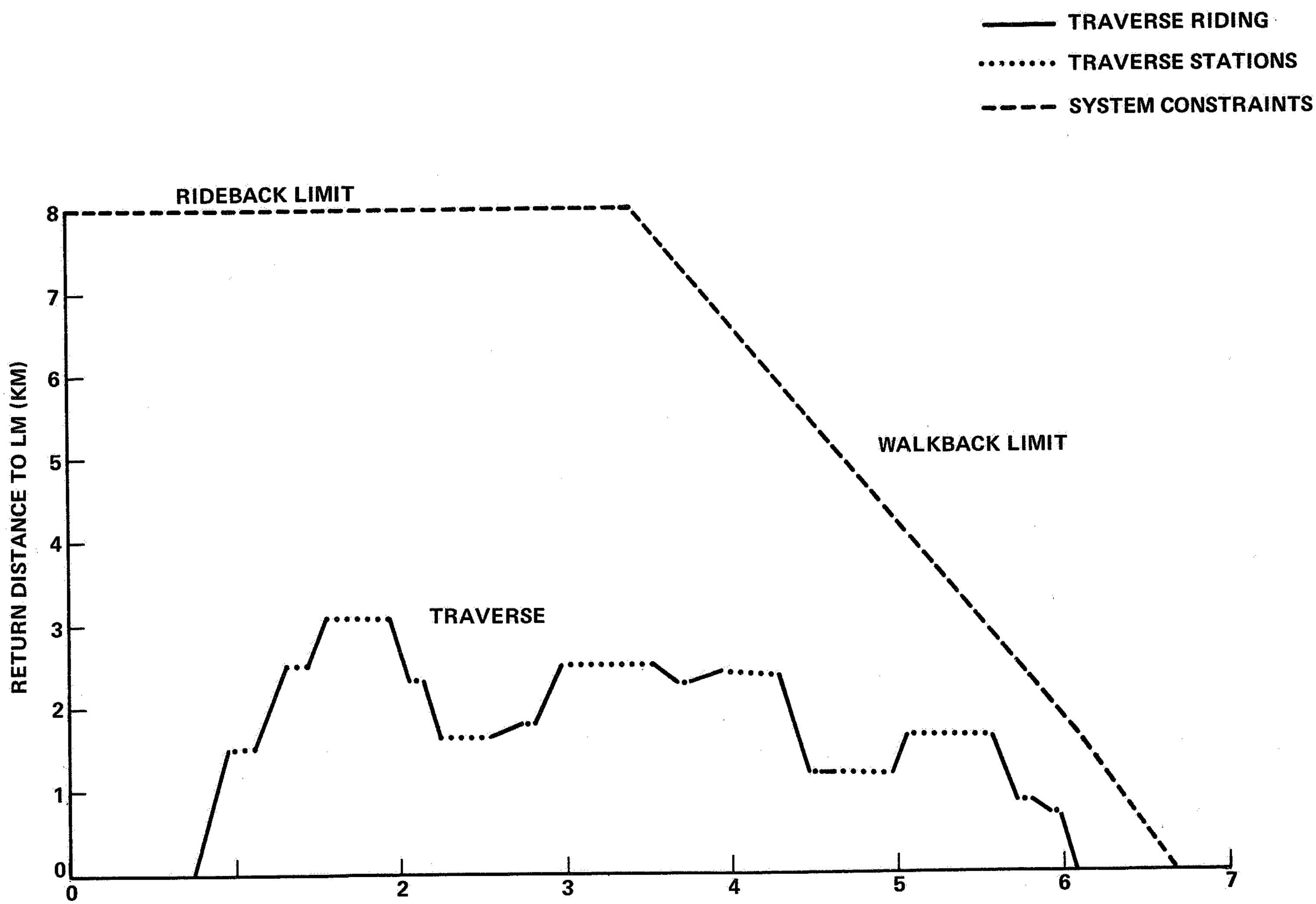

FIGURE C-2 - SYSTEM CONSTRAINTS